INTERLABORATORY STUDY 90-1
TOTAL CYANIDE IN REAGENT WATER AND STP EFFLUENT

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TOTAL CYANIDE IN REAGENT WATER

AND STP EFFLUENT

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1. SUMMARY AND CONCLUSIONS

This interlaboratory study was initiated, as part of an ongoing program of the Quality Management Office (QMO), Laboratory Services Branch (LSB) of the Ontario Ministry of the Environment (MOE), to evaluate the ability of environmental laboratories to measure 'Total Cyanide' in reagent water and in STP effluent.

Thirty four laboratories participated in the study. Four samples in each of the above matrices, to a total of eight, were prepared by the QMO and distributed to the participants. The participants were requested to use their analytical method conforming to the MISA (Municipal and Industrial Strategy for Abatement) regulations. All except one laboratory reported results for all the samples.

The results as they were received were entered on to a LOTUS 123® spreadsheet. A hard -copy of the electronic spreadsheet was sent to all participants for verification. No laboratory reported any transcriptional errors. The majority of the laboratories reported 'not detected' (or less than Method Detection Limit, MDL) for the unspiked reagent water sample. Hence the results of this sample were not used in this study evaluation. Since most laboratories reported significant and variable amounts of 'Total Cyanide', the spiked effluent data results of each laboratory were corrected by subtracting the amount reported by that laboratory for the unspiked effluent.

The performance of the participants was evaluated using a graphical method developed by the QMO[2]. The entire data-set was split into four sub-sets for evaluation. Each sub-set included data from two samples of the same matrix. By a process of iterative elimination of suspect data, the average repeatability (S_w) estimates for each of these sub-sets was determined. The four average S_w estimates obtained were found to be not significantly different from each other. For the purpose of consistency and comparison of evaluation outcomes among the four pairs of data of each laboratory, the average effluent S_w estimate was used to define the warning and control limits for all evaluations.

Laboratories that produced results within the warning limits were appraised as producing acceptable results. These criteria are based on the performance of the most comparable participants. Fourteen laboratories (41% of participants) demonstrated acceptable performance in all evaluations. These laboratories are considered to be capable of generating valid analytical data. Three other laboratories were found to be within control limits in all four evaluations but marginally exceeded the warning limits in one of the four evaluations. The performance of these laboratories may be considered as moderate. Twenty laboratories (59%) produced acceptable data for reagent water samples.

About 40% of the participants in this study produced erratic data. This unusual high percentage of erratic data might be attributed to inadequate control in the sample preparation stage of the analysis. For most 'erratic' laboratories adequate control will improve the quality and comparability of their analytical data.

The observed mean value of the most comparable laboratories for the reagent water samples were essentially equal to the target values. Thus it may be concluded that the comparable laboratories on average are accurate in measuring reagent water samples. As the 'Total Cyanide' of the unspiked STP effluent is not known, the accuracy of measurement of the effluent samples cannot be evaluated.

2 INTRODUCTION

Interlaboratory performance studies or round robins, are conducted for a variety of reasons. These include:

-to assess data comparability and monitor laboratory performance,
-to identify bias and precision or accuracy problems,
-to evaluate analytical methods
-to determine 'true' value for certified reference materials, and,
-to promote self-improvement.

The Quality Management Office (QMO), Laboratory Services Branch (LSB) of the Ontario Ministry of the Environment (MOE) has instituted an on-going program of round robins to assess and promote the performance of environmental laboratories providing analytical services for a variety of different programs.

Interlaboratory Study 90-1 was designed to assess the analytical variability of 'Total Cyanide' in reagent water and STP effluent. 'Total Cyanide' test is included in the test group 2 listed in the MISA (Municipal and Industrial Strategy for Abatement) General Regulation.

Cyanide is environmentally significant in a number of forms. The simple cyanide ion CN^-, and hydrocyanic acid (HCN), which are the forms most toxic to fish are referred to as simple or free cyanides. The complex cyanides such as $(Fe(CN)_6)^{3-}$ and $(Fe(CN)_6)^{4-}$ which can dissociate to form free cyanide are also critical in terms of pollution potential. The 'Total Cyanide' test measures the total potential cyanide present in a sample and includes both the free or simple cyanides and complex cyanides except for complex cobalti cyanide. The test does not, however, include other related classes of compounds such as thiocyanates (SCN) and cyanates(CNO).

Invitations were sent to several laboratories known to the QMO at that time as doing MISA work. Thirty-four laboratories agreed to participate. The participants were requested to use methods conforming to the MISA analytical principles and protocols given in the General Regulation (Ontario Regulation 359/88). One laboratory withdrew from the study after receiving the samples. Another laboratory forwarded two sets of results and these were considered as separate participants in the study evaluation. A list of participants is included in Appendix 1.

Two matrices, namely reagent water and STP effluent were chosen for this study. Four samples in each of the above two matrices to a total of eight, were prepared by the QMO and distributed to the participants.

3. TECHNICAL OUTLINE

3.1 SAMPLE PREPARATION

3.1.1 REAGENTS

i) Deionized Distilled Water (DDW)

ii) Homogenized Non-chlorinated STP Effluent

This effluent was collected from the Lakeview Sewage Treatment Plant (Oakville) on January 11, 1990. The effluent was thoroughly mixed prior to use.

iii) MOE Cyanide Standard, Lot# INM0301

iv) 10 Normal Sodium Hydroxide Solution (10N NaOH)

3.1.2 CYANIDE STANDARD FOR SPIKING

This standard was prepared by the QMO. 2.1093g of Potassium Ferricyanide (Analar grade) and 4.0g of sodium hydroxide pellets (Analar grade) were transferred quantitatively into a 1L volumetric flask containing 800 mL of deionized distilled water (DDW). After thorough mixing until complete dissolution of all solids, additional DDW was added to make up to volume. This standard solution after mixing was dispensed into several 5 mL amber ampoules, flame sealed and stored at room temperature. The concentration of the prepared ampoule was verified by a MOE laboratory by analyzing simultaneously six samples prepared from randomly selected ampoules along with six samples prepared from appropriate EPA (Environmental Protection Agency, U.S.A.) Certified Standard.

Lot#: INMO301 Ampoule size: 5mL (amber)
Date of Validation: Oct. 31, 1989
Designed: 1000 mg/L
Found: 992.2 mg/L 99% confidence interval +/- 103.3 mg/L

3.1.3 PROCEDURE

Secondary Standard Solution

A Secondary Standard Solution was prepared by transferring quantitatively 20.0 mL of Cyanide Standard Solution (INMO301) into a 200 mL volumetric flask containing 100 mL of DDW and 2 mL of 10N NaOH. The volume was made up to 200 mL and the solution was thoroughly mixed.

30L of each type of sample (listed in Table 3.1) was prepared. In every case the appropriate intermediate solution (2L) was prepared by quantitatively transferring designated amounts of Secondary Standard Solution (see Table 3.1) and 300 mL of 10N NaOH solution into a 2L volumetric flask containing approximately 1500 mL of the appropriate matrix. After making up to volume with the same matrix, the entire intermediate solution was transferred into a Nalgene tub containing 28 kg of the appropriate matrix and the solution was mixed thoroughly using a mechanical stirrer. The pH of this solution was verified and in all instances the pH was found to be between 12.0 and 12.5. With the aid of a peristaltic pump approximately 500 mL of this bulk solution was dispensed into appropriately labelled PET sample containers.

TABLE 3.1

Spiking chart for sample preparation

SAMPLE	SPIKING STANDARD Secondary Standard Solution	MATRIX
D1	None	Reagent water (DDW)
D2	9 mL	Reagent water (DDW)
D3	10 mL	Reagent water (DDW)
D4	30 mL	Reagent water (DDW)
E1	None	STP Effluent
E2	9 mL	STP Effluent
E3	10 mL	STP Effluent
E4	30 mL	STP Effluent

3.2 DISTRIBUTION

Prior to sample preparation, the participating laboratories received a letter of notification. The laboratories confirmed their willingness to participate in this study by letter or telephone. Each participant was assigned a laboratory identification code. A list of participating laboratories and examples of correspondence with participants are included in Appendix 1.

A total of eight samples were packaged in cardboard boxes and were shipped to most participants via Purolator courier on January 23, 1991. A few samples were hand delivered. No sample losses in transit were reported. Included with the samples were result reporting forms. The laboratories were requested to briefly describe their sample preparation procedures and instrumental methodology used.

3.3 DATA HANDLING

The majority of the laboratories utilized the result reporting forms to submit their findings to the QMO. All data were manually entered by laboratory code into an electronic spreadsheet.

Tables of results were sent to all participants for verification on March 14, 1990. The participants were requested to report any transcriptional errors before March 31, 1991. No laboratory reported any errors.

4. EVALUATION METHODOLOGY

Evaluation of the laboratory performance in this study was performed by an automated spread-sheet and graphical procedure described in the paper "Classification of Systematic Errors using Two Samples at Different Concentrations" by D.E.King and S.S.Selliah[2].

A step-wise summary of this evaluation procedure is given below.

4.1 Summary of The Two-Sample Performance Evaluation Procedure

1. Split two samples of different concentrations among a number of laboratories for analysis/measurement using their current methodology.

2. Enter data on LOTUS 123® spreadsheet.
   Calculate median (L_m,H_m), means and standard deviations for each sample.
   Tabulate data and return to laboratory analyst for verification.
   Correct database if transcriptional errors were reported.

3. Evaluate high sample data:

   i) reject all results which differ from the median (H_m) by more than 10%
   ii) calculate median(H), mean and standard deviation (S_h)
   iii) re-include data if within 3 times S_h
   iv) reiterate ii) and iii) until no further data is included
   v) calculate relative standard deviation of the final selected data (CV_h)

4. Evaluate low sample data:

   i) use 3 x CV_h x median(L_m) to exclude possible outliers
   ii) calculate median(L), mean and standard deviation (S_l)
   iii) reinclude data if within 3 times S_l)
   iv) reiterate ii) and iii) until no further data is included.

5. Determine paired sample performance criteria:

   i) examine the ratio of S_h/S_l and if:
   <2 use data as reported in concentration units
   otherwise convert to % recovery based on expected value if known (otherwise use median values (H,L))
   ii) prepare paired sample scatter diagrams of all data
   iii) calculate perpendicular distances from each point to the two 45 degree lines (slope and intercept error lines) and select the lesser of the two perpendicular distances (PD)
   iv) determine the median PD
   v) determine the average of all PD values less than 2.5 times the median and use this average to estimate the average repeatability S_w (see reference 3).
   vi) set warning limits for repeatability = 2 times S_w
   vii) set control limits for repeatability = 3 times S_w
   viii) set warning limits for possible bias = 3 times S_w
   ix) set control limits for possible bias = 4.5 times S_w

6. Code performance based on location of points on a Youden-type diagram using LOTUS 123® program:

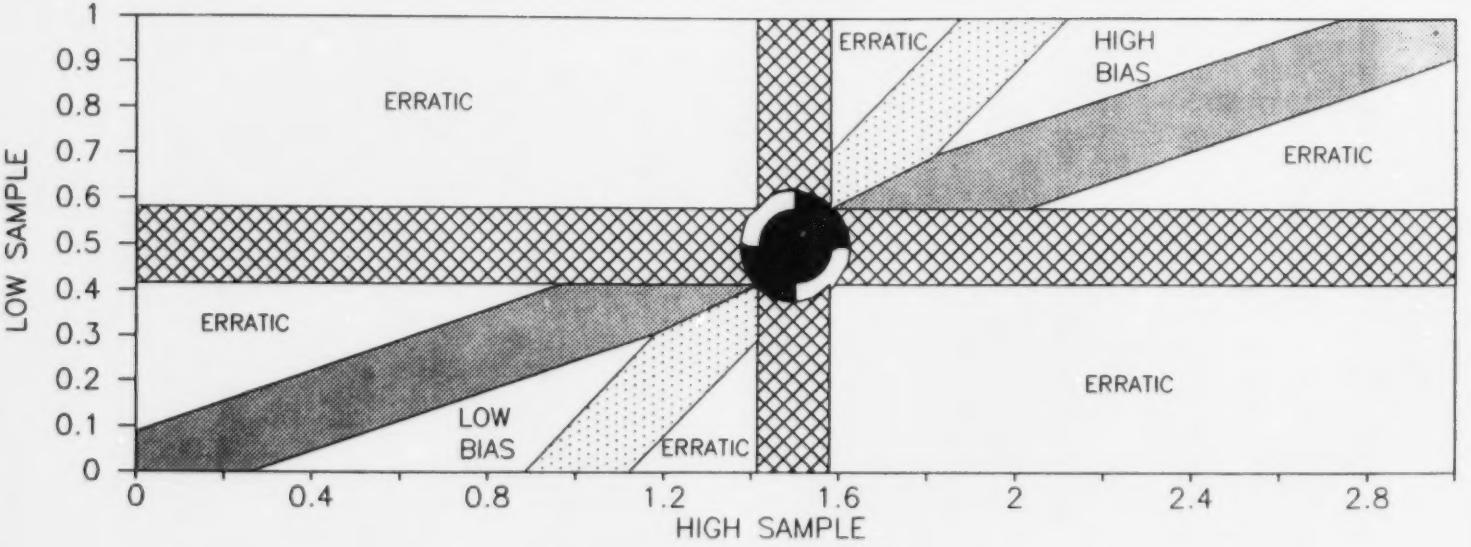
   i) in upper left or lower right quadrant (erratic)
   ii) in lower left or upper right quadrant (biased low or high)
   iii) on horizontal or vertical axis (out of control)
   iv) on diagonal line through origin (slope or standard problems)
   v) on diagonal line not through origin (intercept or blank problems)
   vi) prepare summary table of performance assessment

4.2 Limits for Maximum Interlaboratory Repeatability and Reproducibility

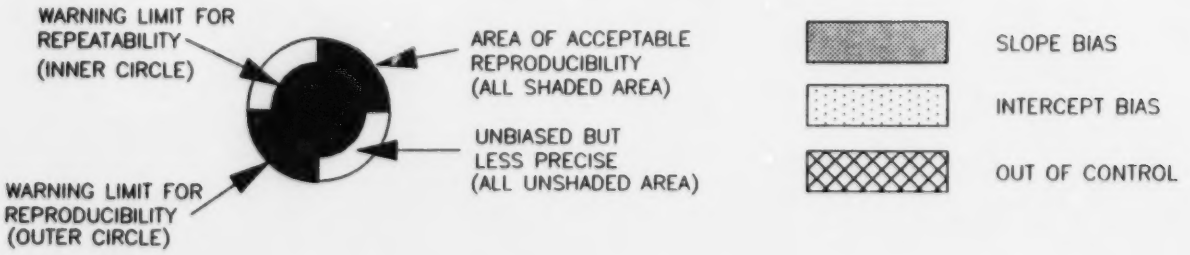
The average perpendicular distance (PD) from the bias lines represents the interlaboratory estimate of within laboratory repeatability. It is used to estimate S_w (see section 4.1). Warning limits and control limits for repeatability are set at $2S_w$ and $3S_w$, respectively. Note that the factors used are somewhat arbitrary but they represent approximately 95% and 99% confidence intervals.

Additional tolerance is required for the effect of variability in preparing and using standards on a day to day or among laboratory basis. But the overall estimate of reproducibility includes data from laboratories with excessive bias. In lieu of this S_r is set as a criterion for acceptable reproducibility. S_r is set at $1.5\ S_w$. Therefore the warning and control limits for reproducibility are set at $3S_w$ and $4.5S_w$ respectively. Based on the f-test a ratio $(S_r/S_w)^2$ exceeding 2.3 (i.e 1.5^2) would be considered significant with a risk of error of less than 10%, 5%, and 1% respectively for 10, 20, and 35 degrees of freedom. Results that exceed warning and control limits determined from this desired maximum interlaboratory (DMI) reproducibility (S_r) are deemed to be possibly or probably biased respectively.

FIGURE 5.0



KEY TO SHADED AREAS


WARNING LIMIT FOR REPEATABILITY (INNER CIRCLE)
AREA OF ACCEPTABLE REPRODUCIBILITY (ALL SHADED AREA)
UNBIASED BUT LESS PRECISE (ALL UNSHADED AREA)
WARNING LIMIT FOR REPRODUCIBILITY (OUTER CIRCLE)
SLOPE BIAS
INTERCEPT BIAS
OUT OF CONTROL

4.3 Two Sample Plot Discussion

The Youden-style graphical presentation enables all participants to visualize how they have performed compared to others. The assessment of a laboratory in this study is based on the location of its result on the graph. Figure 5.0 identifies the various regions in a typical graph associated with the different types of problems that might be experienced by the participants. Laboratories with controlled repeatability but showing various degrees of bias will appear in the lower left and upper right quadrants. The two circles drawn in this diagram represent the warning limits for repeatability (S_w) and reproducibility (S_r). Those points within the outer circle but in the upper left and lower right quadrants (not shaded in Figure 5.0) are unbiased but somewhat less precise. Those points within the circle but in the upper right and lower left quadrants are precise but acceptably biased. Thus the area of acceptable performance in this diagram has taken the shape of a keyhole.

In a typical graphical presentation (Figures 5.1 to 5.4), the actual results of each laboratory constitute the points on the graph. The solid lines dividing the graph into four quadrants represent the median results of appropriate samples. The 'keyhole' shaped area of acceptable performance, described earlier, is the area de-limited by the inner circle and the outer arcs in the lower left and upper right quadrants. All laboratories that lie outside this area have exceeded the respective warning limits. The two dotted lines are drawn across the graph representing the slope (concentration) dependant error and the intercept (blank) dependant error. The laboratories that exhibit these types of biases will lie along these lines. All laboratories exceeding warning limits have been identified by their laboratory codes. These laboratories can readily see the nature of their particular problems.

5. RESULTS AND DISCUSSION

Each laboratory received a total of eight samples consisting of an unspiked sample, two low spikes and one high spike sample in each of the two matrices. All but one laboratory reported results for all the 8 samples. As expected the majority of the laboratories reported 'not detected' (or less than detection limits) for the unspiked reagent water sample. Hence, the results of this sample were not used in the graphical evaluation. However, most laboratories (>70%) reported significant amounts of total cyanide in the unspiked effluent sample. This 'blank' data was highly variable amongst laboratories and this 'blank' variability in turn appeared to influence the spiked effluent data. When the spiked effluent result for each laboratory was corrected by subtracting the amount reported by that laboratory for the unspiked effluent, the variability was reduced and the data was more amenable to Youden-type graphical evaluation as described in section 4. The following sub-sets of data were extracted from the entire data set for evaluation.

a) Sample D2 versus sample D4 (one low and high spike in reagent water). This set of data will be identified in this report as **D24**.

b) Sample D3 versus sample D4 (other low and high spike in reagent water). This set of data will be identified in this report as **D34**.

c) Sample $E2_{corr.}$ versus sample $E4_{corr.}$ (one low and high spike in STP effluent). This set of data will be identified in this report as **E24corr.**

d) Sample $E3_{corr.}$ versus sample $E4_{corr.}$ (other low and high spike in STP effluent). This set of data will be identified in this report as **E34corr.**

Each of the above four data sets was evaluated separately. Accordingly, each pair of results of a laboratory corresponding to the above four sets of data are assessed individually. The outcomes of the four evaluations were then considered in the overall assessment of individual laboratory performance.

Warning and control limits have been used as the basis to flag laboratories that did not demonstrate acceptable repeatability or reproducibility.

The term 'acceptable' throughout these evaluations is based on overall average repeatability of those participants reporting comparable data. In some cases, closer scrutiny of the plotted results suggests that the limits could have been tightened (i.e. some laboratories are more repeatable than others). This was not pursued in this study.

As mentioned earlier four sets of data were treated by the procedure described in section 4. The outcome of each of these evaluations are summarized in tables 9.3.1 to 9.3.4 (section 9) and Figures 5.1 to 5.4. Each table shows the results reported by each participating laboratory along with other statistical information. The four average repeatability S_w estimates obtained from these four sets of data were found to be not significantly different from each other. For the purpose of consistency and comparison of evaluation outcomes between the pairs of data for each laboratory, the repeatability estimate obtained for the effluent samples (S_w =0.0055) was used to define the appropriate warning and control limits for all four sets of data. The outcome of the evaluation of each laboratory is recorded in the extreme right column. Those laboratories that fall in the warning range (i.e., laboratories that exceed the warning limits but fall within the control limits) are identified with the prefix 'Warning' followed by the type of error. Also, included in these tables are estimates of 'total error' for those participants that have exceeded the warning and control limits. The total error of a laboratory for a particular evaluation is the distance, in units of S_w, from the point representing its results in the appropriate graph to the point of intersection of the two median lines.

5.1 SUMMARY OF RESULTS FROM PARTICIPATING LABORATORIES

An overview of performance of each laboratory in all four evaluations is presented in Table 5.0. The key to this summary table is as follows:

A	Acceptable performance
Ll	Biased low, possible intercept problem
LI	Biased low, probable intercept problem
Ls	Biased low, possible slope problem
LS	Biased low, probable slope problem
L	Biased low
Le	Biased low and/or erratic
Hl	Biased high, possible intercept problem
HI	Biased high, probable intercept problem
Hs	Biased high, possible slope problem
HS	Biased high, probable slope problem
H	Biased high
He	Biased high and/or erratic
OC	Out of control-one result erratic
ER	Both results erratic
WAl	Warning: Slight imprecision
WLI	Warning: Biased low, probable intercept problem
WHI	Warning: Biased high, probable intercept problem
WHS	Warning: Biased high, probable slope problem
WOC	Warning: Out of control-one result erratic

TABLE 5.0
SUMMARY OF OVERALL LABORATORY PERFORMANCE

	D24	D34	E24corr.	E34corr.
Lab.Code				
5001	WHS	WOC	OC	OC
5002	A	A	LS	OC
5003	A	A	A	A
5004	A	A	A	A
5005	A	A	A	A
5006	OC	OC	A	A
5008	WOC	OC	L	LS
5009	WOC	A	A	OC
5010	A	A	A	A
5011	A	WAI	LS	LS
5011A	OC	LS	LI	OC
5012	WAI	A	A	A
5013	A	A	A	A
5014	A	A	A	A
5015	A	A	A	WHI
5016	Ls	LS	LS	Ls
5017	ER	LS	ER	OC
5018	A	A	A	
5019	A	A	A	WAI
5020	A	A	A	A
5021	He	He	ER	ER
5022	A	A	A	A
5023	A	WLI	LI	LI
5024	A	A	A	A
5025	A	A	OC	ER
5026	WAI	A	OC	LS
5027	A	A	Li	LS
5028	A	A	ER	ER
5029	A	OC	A	A
5030	A	A	A	A
5031	A	A	A	A
5032	H	H	He	He
5033	A	A	A	A
5034	A	A	A	A

Fourteen laboratories (41% of the total participants) were found to be within the limits of acceptable performance in all four evaluations. These laboratories are considered as overall good or acceptable performers and are capable of generating valid analytical data. Three other laboratories found to be within control limits in all four evaluations but marginally exceeded warning limits in one of the four evaluations. The performance of these laboratories may be considered as moderate. In addition to the fourteen laboratories that produced acceptable results in all four evaluations, six other laboratories were able to produce acceptable results for reagent water samples but had problems measuring the more complex matrix (STP effluent) samples.

As the observed mean values of most comparable laboratories for the spiked reagent water samples were essentially equal to the target values, it may be concluded that the comparable laboratories on average are accurate in measuring reagent water samples.

The Youden diagrams indicate generally acceptable recovery of the cyanide added to the effluent matrix. Although many laboratories including those graded as overall acceptable performers reported considerable and variable amounts of total cyanides for the unspiked STP effluent. The non-chlorinated STP effluent used in this study was tested for 'Total Cyanide' prior to its use. No 'Total Cyanide' was found. The high variability of reported values for the unspiked effluent amongst participants is of some concern. While some laboratories reported values close to their MDL's (Method Detection Limits) many reported values that far exceeded their MDL's. Since the unspiked reagent water sample did not reveal any significant problems with laboratory blanks, the high variability of the effluent sample might be related to the matrix or to variable recovery of complex cyanides in the sample.

About 40 % of the participants in this study produced erratic data. This observation is very unusual for a study of this size and nature. The test for total cyanide includes measurement of both simple and complex cyanides present in the sample. It does not include other related classes of compounds such as cyanates and thiocyanates that are likely to be present in a sample. The analysis, for the majority of the participants, involves a distillation step (sample preparation) prior to the measurement process. The acid distillation converts selectively the complex cyanides to simple cyanides which are then measured either directly (ion-selective electrode, ion chromatography) or colorimetrically after conversion to a suitable coloured complex.

A review of the analytical procedures used by these laboratories (Table 8.0, section 8) did not reveal any correlation between the methods and the erratic behaviour. Neither does sample size used by participating laboratories have any correlation to the evaluation outcomes. As the samples were prepared in bulk and continuously mixed throughout the dispensing, non-homogeneity of samples as a possible cause of this erratic behaviour can be ruled out.

In the author's experience with the cyanide analysis, the distillation step must be very carefully controlled. Improper choice of digestion acid and/or inadequate operating control can allow other interfering volatile compounds present in the sample to distil over leading to over-recovery. Leaks in the manual distillation system can lead to poor recovery.

The analytical methodology used by participants in this study is summarized in Table 8.0 (Section 8). Acid distillation appears to be the popular choice of sample preparation for the participants. One laboratory reported UV digestion prior to distillation. It is interesting to note that this laboratory was not only within the limits of acceptable performance in all four evaluations, but also reported minimal amount (0.005 mg/L) of 'Total Cyanide' in unspiked effluent. Most laboratories (79%) used colorimetry for the instrumental measurement. Five laboratories reported using ion selective electrode methodology.

5.2 ASSESSMENT OF INDIVIDUAL LABORATORY PERFORMANCE

Laboratory 5001
This laboratory is flagged in all four evaluations. They tend to have problems with high concentration samples. The high slope bias is masked by the erratic nature of their data.

Laboratory 5002
This laboratory, even though showing acceptable performance in reagent water, shows an overall erratic behaviour.

Laboratories 5003, 5004, & 5005
Acceptable performance.

Laboratory 5006
This laboratory while demonstrating the capability of producing acceptable results in five spiked samples, produced a low result for the high reagent water spike causing this laboratory to be flagged (out of control) in 2 of the 4 evaluations.

Laboratory 5008
This laboratory is flagged in all four evaluations. The size and the variability of their blanks exceeds the sensitivity required to measure the spikes.

Laboratory 5009
This laboratory is out of control.

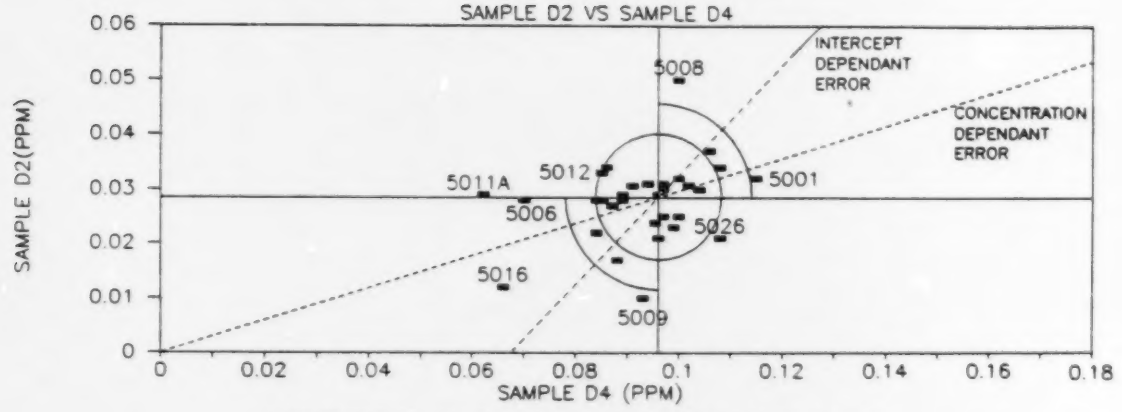
Laboratory 5010
Acceptable performance.

Laboratory 5011
This laboratory is flagged in three out of four evaluations. The examination of all six spiked data conforms the low slope bias shown in the evaluation of effluent data.

Laboratory 5011A
This laboratory is flagged in all four evaluations. The laboratory is out of control producing erratic data.

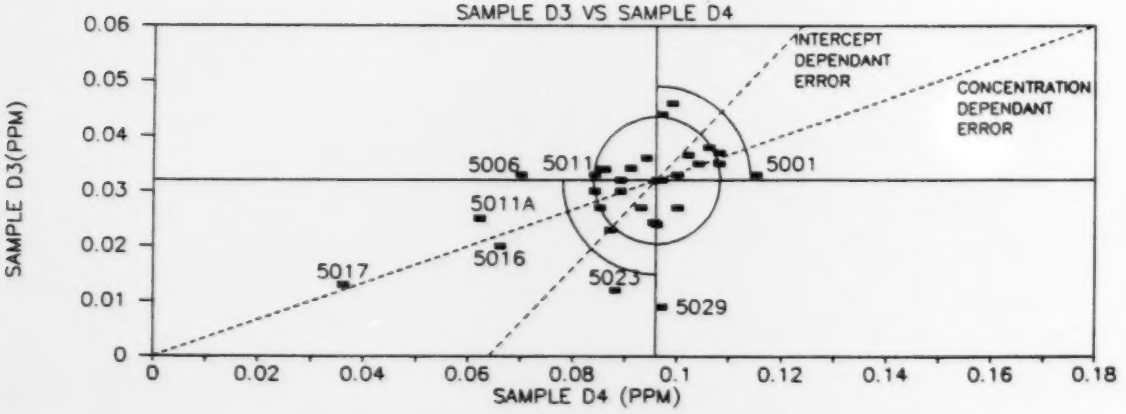
MATRIX: REAGENT WATER

FIGURE 5.1



LABORATORIES 5017, 5021 & 5032 ARE OUTSIDE SCALE

FIGURE 5.2



LABORATORIES 5008, 5021 & 5032 ARE OUTSIDE SCALE

Laboratory 5012
This laboratory, although within control limits in all four evaluations, tends to be slightly imprecise.

Laboratories 5013 & 5014
Acceptable performance.

Laboratory 5015
This laboratory, although within control limits in all four evaluations, received a warning in one of the effluent evaluations. Examination of all six spiked results shows a tendency to be biased high but the nature of the bias cannot be confirmed due to the imprecision this data set.

Laboratory 5016
This laboratory is flagged in all four evaluations as having a low slope bias.

Laboratory 5017
This laboratory is flagged in all four evaluations. The erratic nature of their data set shows that the laboratory is out of control.

Laboratory 5018
Acceptable performance.

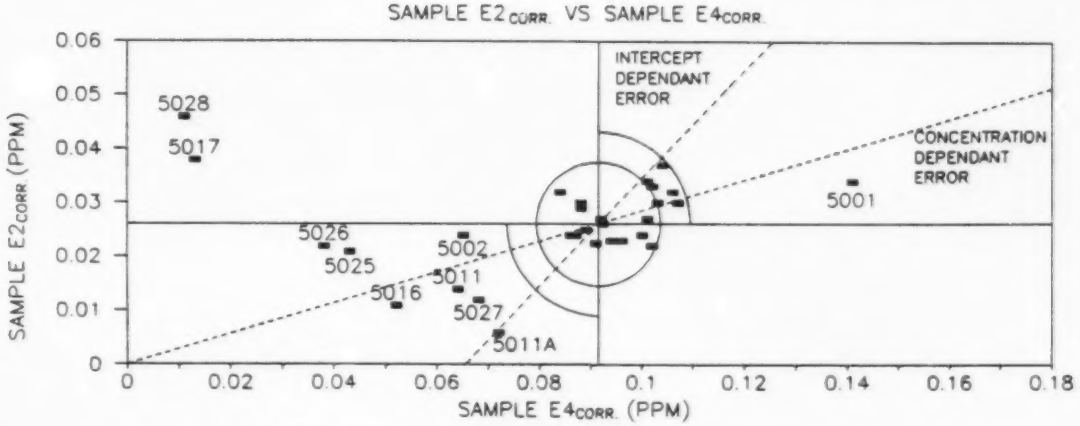
Laboratory 5019
This laboratory although within control limits in all four evaluations received a warning as being slightly imprecise in one of the two effluent evaluations.

Laboratory 5020
Acceptable performance.

Laboratory 5021
All the results of this laboratory are biased high. It is not possible to identify the nature of their biases due to the erratic nature of their data. The laboratory is out of control.

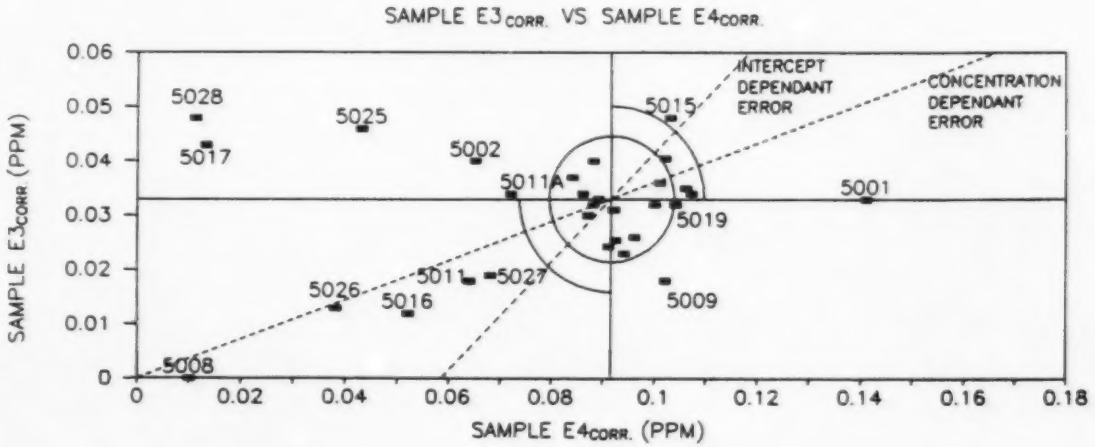
MATRIX: LAKEVIEW STP EFFLUENT

FIGURE 5.3



LABORATORIES 5008, 5021, 5023 & 5032 ARE OUTSIDE SCALE

FIGURE 5.4



LABORATORIES 5021, 5023 & 5032 ARE OUTSIDE SCALE

Laboratory 5022
Acceptable performance.

Laboratory 5023
All the results of this laboratory are biased low and are intercept dependant. In the case of the effluent samples the low intercept dependant bias is partly due to the 'high' value reported by this laboratory for the unspiked effluent sample.

Laboratory 5024
Acceptable performance.

Laboratories 5025 & 5026
The erratic nature of the data shows that these two laboratories are out of control.

Laboratory 5027
This laboratory while being able to produce acceptable results for reagent water, produced low biased results for effluent sample. Due to the slight imprecision observed with their effluent data, the exact nature of the low bias cannot be identified. An error in estimating the 'blank' value in unspiked effluent may also have contributed towards the failure to produce acceptable results for the effluent samples.

Laboratory 5028
This laboratory while being able to produce acceptable results for reagent water samples produced erratic results for the effluent sample. The laboratory is out of control.

Laboratory 5029
This laboratory while demonstrating the capability of producing acceptable results in five spiked samples, produced a extremely low result for one of the lower concentration reagent water sample. This unusual low result suggest, that the laboratory is out of control.

Laboratories 5030 & 5031
Acceptable performance.

Laboratory 5032
This laboratory is flagged in all four evaluations. The results are erratic and biased high. The laboratory is out of control.

Laboratories 5033 & 5034
Acceptable performance.

6. BIBLIOGRAPHY

1. Ontario Regulation 695/88 under the Environmental Protection Act; Effluent Monitoring General.

2. Classification of Systematic Errors using Two Samples at Different Concentrations, D.E.King & S.S.Selliah, *in preparation*.

3. Graphical Diagnosis of Interlaboratory Test Results, W.J.Youden, Industrial Quality Control, XV, No 11, May 1959.

7. APPENDIX 1 - LIST OF PARTICIPANTS & CORRESPONDENCE

LIST OF PARTICIPANTS

1. Accurassay Ltd.
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4. ASL Analytical Service Laboratories Ltd.
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MOE INTERLABORATORY VARIABILITY STUDY NOTIFICATION FOR THE ANALYIS OF TRACE INORGANIC COMPOUNDS

STUDY NO. 90-1

INTRODUCTION

Laboratories receiving this notification are invited by the Ontario Ministry of the Environment, Laboratory Services Branch, to participate in an interlaboratory variability study of spiked reagent water and spiked mixed effluent, conducted using MISA analysis protocols. Laboratories interested in participating in this program, scheduled for the week of January 15, 1990, should contact Sylvia Cussion at (416) 235-5842 or Catherine Doehler (416) 235-6055 of the Ministry of the Environment to confirm participation. Written confirmation (attached response sheet) must be submitted to the Ministry of the Environment no later than January 10, 1990 (FAX - (416) 235-5744).

BACKGROUND

This study is being conducted to assist laboratories in assessing their analytical performance. All procedures should follow those principles and protocols outlined in the MISA regulations (Ontario Reg. 695/88, as amended to Ontario Regulation 533/89). Sample sets will include four samples per matrix: a blank, two low spikes (approx. 5-10 times the Regulation MDL), and a high spike (approx. 20 times the Regulation MDL).

NOTE: Any laboratory that does not have a copy of the MISA general regulations should contact Catherine Doehler for additional information.

The following test group is to be included in this study:

Total Cyanide
(MISA Group 2)

Time Limit: 7 days storage
Samples will be preserved with NaOH.

SCHEDULE

During the week of January 15, 1990 participating laboratories will receive a total of eight (8) samples divided as follows: four (4) reagent water samples and four (4) mixed effluent samples. All samples will be for the analysis of Total Cyanide.

Participating laboratories are expected to analyze the samples within the time limits specified in Schedule 2 of the general MISA regulations (Ontario Reg. 695/88). Blank reporting forms will be provided with the samples. Results for all analyses are to be reported within thirty (30) days of receipt of the samples to Sylvia Cussion/Catherine Doehler at the following address:

Ministry of the Environment
Laboratory Services Branch
Quality Assurance Unit
125 Resources Rd., P.O. Box 213
Rexdale, Ontario
M9W 5L1

SUMMARY OF RESULTS

All participating laboratories will be assigned a unique identification code. All laboratories reporting results will receive a complete set of the results, including a ranking for each laboratory where they will be identified only by their identification code. Recommendations made by the MOE will also be provided to the individual labs. Results will remain confidential and will only be released with the written permission of the individual participants.

It is the intent of this interlaboratory study (along with others) to assess the interlaboratory variability and detection capability for a broad range of organics and inorganics.

MOE INTERLABORATORY VARIABILITY STUDY NOTIFICATION FOR THE ANALYIS OF TRACE INORGANIC COMPOUNDS

STUDY NO. 90-1

YES NO

We will participate in MOE Study 90-1 for the analysis of Total Cyanide.

Minimum amount of sample volume required: _____

For the completeness of our records, and to avoid any shipping delays, please fill in the following:

Mailing Address: Shipping Address:

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

Contact Person: _____

Phone Number: _____

Please return this questionnaire before January 10, 1990 to:

Sylvia Cussion/Catherine Doehler
Ontario Ministry of the Environment
Laboratory Services Branch
Quality Assurance Unit
125 Resources Rd.
Rexdale, Ontario
M9W 5L1
(416) 235-5842 or 235-6055

Laboratory Services Branch
Quality Assurance Unit
125 Resources Road
Rexdale, Ontario
M9W 5L1
(416) 235-5842 or 235-6055
FAX (416) 235-5744

January 23, 1990

TO: PARTICIPANTS OF INTERLABORATORY STUDY 90-1

Please find enclosed eight 500 mL plastic bottles. The samples are labelled as follows:

Distilled water:	D1	D2	D3	D4
Effluent:	E1	E2	E3	E4

If you are missing any of the above items, please contact us at the above phone number immediately.

As stated in the notification distributed December 11, 1989, samples should be analyzed using the principles and protocols outlined in the MISA General Regulation (Ontario Reg. 695/88, as amended to Ont. Reg. 533/89). Store all samples in a refrigerator at 4 degrees Celsius until ready for analysis. Time limit for storage is 7 days.

To ensure timely release of a summary report, results are to be submitted by February 28, 1990. Report forms to be used are included with the samples. Please identify all sample results with your lab identification number and the sample numbers described above. Please contact us if there are any problems or questions re the interlaboratory study. Thank you for your participation.

Your lab identification number is:

Sincerely,

Sylvia Cussion
Lab Quality Audit Scientist
(416) 235-5842

Cathy Doehler
MISA Audit Scientist
(416) 235-6055

INTERLABORATORY STUDY 90-1

REPORT FORM

IDENTIFICATION CODE:

SAMPLE	RESULT
D1	
D2	
D3	
D4	
E1	
E2	
E3	
E4	

SAMPLE PREPARATION PRINCIPLES:

INSTRUMENTAL MEASUREMENT METHOD PRINCIPLES:

Laboratory Services Branch
Quality Assurance Unit
125 Resources Road
Rexdale, Ontario
M9W 5L1
(416) 235-5842 or 235-6055
FAX (416) 235-5744

March 14, 1990

TO: PARTICIPANTS OF INTERLABORATORY STUDY 90-1

Thank you for your participation in Interlaboratory Study 90-1 for the analysis of Total Cyanide in reagent water and effluent. Attached is the table of results from all of the participants, identified by laboratory code. Please review your data for transcription errors and report any changes to me by March 31, 1990. After this date, all results will be considered final and will be used to prepare the final report. All participants will receive a copy of the final report as soon as it becomes available.

Please contact me if you have any questions.

Sincerely,

Sylvia Cussion
Lab Quality Audit Scientist
(416) 235-5842

8. APPENDIX 2 - SUMMARY OF ANALYTICAL METHODOLOGY USED

TABLE 8.0
Summary of analytical methods used

Lab code	Analytical Methodology
5001	Manual distillation,colorimetry-PY/BA
5002	Acid distillation, colorimetry-INA/BA
5003	Tartaric acid distillation, colorimetry-INA/BA
5004	H_2SO_4 distillation, manual colorimetry-PY/BA
5005	$MgCl_2/H_3PO_4$ distillation, colorimetry-INA/BA
5006	Acid distillation,colorimetry
5008	Tartaric acid distillation, colorimetry
5009	Reflux-distillation, specific ion electrode
5010	$NH_2OH.HCl/MgCl_2$ distillation, colorimetry-INA/BA
5011	Tartaric acid distillation, ISE
5011A	Tartaric acid distillation, ISE
5012	Acid distillation, colorimetry
5013	$NH_2OH.HCl$ distillation, colorimetry-INA/BA
5014	Acid distillation, colorimetry-INA/BA
5015	Acid distillation, colorimetry-INA/BA
5016	No information
5017	Manual distillation, colorimetry-INA/BA
5018	$MgCl_2/H_2SO_4$ distillation, manual colorimetry
5019	Acid distillation-colorimetry
5020	Tartaric acid distillation, colorimetry-INA/BA
5021	EPA method D2036-Method A, colorimetry
5022	Distillation, colorimetry-PY/BA
5023	Distillation, colorimetry
5024	No information
5025	5% H_2SO_4 distillation, colorimetry-PY/BA
5026	Tartaric acid distillation, colorimetry-INA/BA
5027	Tartaric acid distillation, colorimetry-PY/BA
5028	Distillation std.mtd, selective electrode mtd.
5029	$NH_2OH.HCl/MgCl_2$ Distillation, selective ion electrode
5030	$H_2SO_4/MgCl_2$ distillation, colorimetry-PY/BA
5031	Acid distillation, colorimetry
5032	Tartaric acid distillation, colorimetry-PY/BA
5033	UV digestion-distillation, colorimetry-PY/BA
5034	Acid distillation, colorimetry

9. APPENDIX 3 - SUMMARY OF DATA FOR ALL PARTICIPANTS

TABLE 9.1
Summary of results as reported by participants
Reagent Water Samples
(mg/L)

Lab Code	Sample D1	Sample D2	Sample D3	Sample D4
Spike	0	0.030	0.033	0.100
5001	0.001	0.032	0.033	0.115
5002	<.005	0.034	0.034	0.086
5003	<.005	0.021	0.024	0.096
5004	<.0005	0.0306	0.0342	0.0910
5005	<.001	0.034	0.037	0.108
5006	<0.005	0.028	0.033	0.070
5008	0.07	0.05	0.09	0.10
5009	0.007	0.010	0.027	0.093
5010	<.005	0.037	0.038	0.106
5011	0.059	0.022	0.033	0.084
5011A	0.003	0.029	0.025	0.062
5012	0.035	0.033	0.027	0.085
5013	<.005	0.027	0.023	0.087
5014	<.002	0.0307	0.0366	0.102
5015	0.003	0.031	0.044	0.097
5016	<.005	0.012	0.02	0.066
5017	<.005	0.108	0.013	0.036
5018	<.005	0.029	0.032	0.089
5019	<.005	0.030	0.032	0.097
5020	0.0003	0.029	0.032	0.096
5021	<0.03	0.62	0.92	2.86
5022	<.005	0.0238	0.0243	0.0954
5023	0.002	0.017	0.012	0.088
5024	<.002	0.028	0.030	0.084
5025	0	0.023	0.046	0.099
5026	<.001	0.021	0.035	0.108
5027	<.005	0.032	0.033	0.100
5028	<0.005	0.028	0.034	0.085
5029	<.007	0.025	0.009	0.097
5030	<.002	0.025	0.027	0.100
5031	<0.005	0.028	0.030	0.089
5032	0.04	0.11	0.13	0.23
5033	<mdl	0.031	0.036	0.094
5034	>.005	0.03	0.035	0.104

TABLE 9.2
Summary of results as reported by participants
STP Effluent Samples
(mg/L)

Lab.Code	Sample E1	Sample E2	Sample E3	Sample E4
Spike	0	0.030	0.033	0.100
5001	0.046	0.080	0.079	0.187
5002	<.005	0.024	0.040	0.065
5003	0.021	0.053	0.058	0.105
5004	0.0517	0.0778	0.0771	0.144
5005	0.055	0.085	0.089	0.162
5006	<.005	0.024	0.034	0.086
5008	0.22	0.20	0.22	0.23
5009	0.018	0.04	0.036	0.12
5010	0.018	0.05	0.053	0.124
5011	0.015	0.029	0.033	0.079
5011A	0.015	0.021	0.049	0.087
5012	0.023	0.052	0.063	0.111
5013	0.009	0.036	0.045	0.11
5014	0.004	0.0371	0.0445	0.106
5015	<0.003	0.030	0.048	0.103
5016	0.015	0.026	0.027	0.067
5017	0.022	0.060	0.065	0.035
5018	0.053	0.087	-	0.154
5019	0.056	0.093	0.088	0.160
5020	0.024	0.047	0.050	0.120
5021	2.14	1.90	1.76	4.91
5022	<.005	0.0225	0.0243	0.0910
5023	0.051	0.033	0.039	0.096
5024	0.033	0.058	0.066	0.122
5025	0	0.021	0.046	0.043
5026	<.005	0.022	0.013	0.038
5027	0.039	0.051	0.058	0.107
5028	<.005	0.046	0.048	0.011
5029	0.017	0.044	0.048	0.109
5030	<.002	0.024	0.032	0.100
5031	0.010	0.034	0.040	0.097
5032	0.11	0.18	0.21	0.48
5033	0.005	0.035	0.037	0.093
5034	0.088	0.111	0.111	0.182

TABLE 9.3.1
MOE INTERLABORATORY STUDY 90-1
EVALUATION D24
(All result are expressed in mG/L)

Lab.Code	D2	D4	Total Error	
5001	0.032	0.115	3.4	WARNING:BIASED HIGH, PROBABLE SLOPE
5002	0.034	0.086		ACCEPTABLE PERFORMANCE
5003	0.021	0.096		ACCEPTABLE PERFORMANCE
5004	0.0306	0.091		ACCEPTABLE PERFORMANCE
5005	0.034	0.108		ACCEPTABLE PERFORMANCE
5006	0.028	0.07	4.6	ONE RESULT ERRATIC
5008	0.05	0.1	3.9	WARNING:ONE RESULT ERRATIC
5009	0.01	0.093	3.3	WARNING:ONE RESULT ERRATIC
5010	0.037	0.106		ACCEPTABLE PERFORMANCE
5011	0.022	0.084		ACCEPTABLE PERFORMANCE
5011A	0.029	0.062	6.1	ONE RESULT ERRATIC
5012	0.033	0.085	2.1	WARNING SLIGHT IMPRECISION
5013	0.027	0.087		ACCEPTABLE PERFORMANCE
5014	0.0307	0.102		ACCEPTABLE PERFORMANCE
5015	0.031	0.097		ACCEPTABLE PERFORMANCE
5016	0.012	0.066	6.1	BIASED LOW, POSSIBLE SLOPE PROBLEM
5017	0.108	0.036	17.9	BOTH RESULTS ERRATIC
5018	0.029	0.089		ACCEPTABLE PERFORMANCE
5019	0.03	0.097		ACCEPTABLE PERFORMANCE
5020	0.029	0.096		ACCEPTABLE PERFORMANCE
5021	0.62	2.86	509.6	BIASED HIGH OR ERRATIC
5022	0.0238	0.0954		ACCEPTABLE PERFORMANCE
5023	0.017	0.088		ACCEPTABLE PERFORMANCE
5024	0.028	0.084		ACCEPTABLE PERFORMANCE
5025	0.023	0.099		ACCEPTABLE PERFORMANCE
5026	0.021	0.108	2.5	WARNING SLIGHT IMPRECISION
5027	0.032	0.1		ACCEPTABLE PERFORMANCE
5028	0.028	0.085		ACCEPTABLE PERFORMANCE
5029	0.025	0.097		ACCEPTABLE PERFORMANCE
5030	0.025	0.1		ACCEPTABLE PERFORMANCE
5031	0.028	0.089		ACCEPTABLE PERFORMANCE
5032	0.11	0.23	28.2	BIASED HIGH
5033	0.031	0.094		ACCEPTABLE PERFORMANCE
5034	0.03	0.104		ACCEPTABLE PERFORMANCE

TARGET	0.030	0.100
MEAN OVERALL	0.050	0.176
MEAN SELECTED	0.028	0.095
MEDIAN OVERALL	0.029	0.096
MEDIAN SELECTED	0.029	0.096
S.OVERALL	0.101	0.468
S.SELECTED	0.007	0.008
# OF PARTICIPANTS	34	34
# SELECTED	30	27

TABLE 9.3.2
MOE INTERLABORATORY STUDY 90-1
EVALUATION D34
(All results are expressed in mG/L)

Lab.Code	D3	D4	Total error	
5001	0.033	0.115	3.4	WARNING: ONE RESULT ERRATIC
5002	0.034	0.086		ACCEPTABLE PERFORMANCE
5003	0.024	0.096		ACCEPTABLE PERFORMANCE
5004	0.0342	0.091		ACCEPTABLE PERFORMANCE
5005	0.037	0.108		ACCEPTABLE PERFORMANCE
5006	0.033	0.07	4.6	ONE RESULT ERRATIC
5008	0.09	0.1	10.4	ONE RESULT ERRATIC
5009	0.027	0.093		ACCEPTABLE PERFORMANCE
5010	0.038	0.106		ACCEPTABLE PERFORMANCE
5011	0.033	0.084	2.1	WARNING SLIGHT IMPRECISION
5011A	0.025	0.062	6.2	BIASED LOW, PROBABLE SLOPE PROBLEM
5012	0.027	0.085		ACCEPTABLE PERFORMANCE
5013	0.023	0.087		ACCEPTABLE PERFORMANCE
5014	0.0366	0.102		ACCEPTABLE PERFORMANCE
5015	0.044	0.097		ACCEPTABLE PERFORMANCE
5016	0.02	0.066	5.8	BIASED LOW, PROBABLE SLOPE PROBLEM
5017	0.013	0.036	11.3	BIASED LOW, PROBABLE SLOPE PROBLEM
5018	0.032	0.089		ACCEPTABLE PERFORMANCE
5019	0.032	0.097		ACCEPTABLE PERFORMANCE
5020	0.032	0.096		ACCEPTABLE PERFORMANCE
5021	0.92	2.86	523.4	BIASED HIGH OR ERRATIC
5022	0.0243	0.0954		ACCEPTABLE PERFORMANCE
5023	0.012	0.088	3.8	WARNING: BIASED LOW, PROBABLE INTERC
5024	0.03	0.084		ACCEPTABLE PERFORMANCE
5025	0.046	0.099		ACCEPTABLE PERFORMANCE
5026	0.035	0.108		ACCEPTABLE PERFORMANCE
5027	0.033	0.1		ACCEPTABLE PERFORMANCE
5028	0.034	0.085		ACCEPTABLE PERFORMANCE
5029	0.009	0.097	4.1	ONE RESULT ERRATIC
5030	0.027	0.1		ACCEPTABLE PERFORMANCE
5031	0.03	0.089		ACCEPTABLE PERFORMANCE
5032	0.13	0.23	29.9	BIASED HIGH
5033	0.036	0.094		ACCEPTABLE PERFORMANCE
5034	0.035	0.104		ACCEPTABLE PERFORMANCE
TARGET	0.033	0.100		
MEAN OVERALL	0.061	0.176		
MEAN SELECTED	0.030	0.095		
MEDIAN OVERALL	0.033	0.096		
MEDIAN SELECTED	0.032	0.096		
S.OVERALL	0.151	0.468		
S.SELECTED	0.008	0.008		
# OF PARTICIPANTS	34	34		
# SELECTED	30	27		

TABLE 9.3.3
MOE INTERLABORATORY STUDY 90-1
EVALUATION E24corr.
(All results are expressed in mG/L)

Lab.Code	E2corr.	E4corr.	Total error	
5001	0.034	0.141	9.0	ONE RESULT ERRATIC
5002	0.024	0.065	4.7	BIASED LOW, PROBABLE SLOPE PROBLEM
5003	0.032	0.084		ACCEPTABLE PERFORMANCE
5004	0.0261	0.0923		ACCEPTABLE PERFORMANCE
5005	0.03	0.107		ACCEPTABLE PERFORMANCE
5006	0.024	0.086		ACCEPTABLE PERFORMANCE
5008	-0.02	0.01	16.8	BIASED LOW
5009	0.022	0.102		ACCEPTABLE PERFORMANCE
5010	0.032	0.106		ACCEPTABLE PERFORMANCE
5011	0.014	0.064	5.4	BIASED LOW, PROBABLE SLOPE PROBLEM
5011A	0.006	0.072	5.0	BIASED LOW, PROBABLE INTERCEPT PROBL
5012	0.029	0.088		ACCEPTABLE PERFORMANCE
5013	0.027	0.101		ACCEPTABLE PERFORMANCE
5014	0.0331	0.102		ACCEPTABLE PERFORMANCE
5015	0.03	0.103		ACCEPTABLE PERFORMANCE
5016	0.011	0.052	7.6	BIASED LOW, PROBABLE SLOPE PROBLEM
5017	0.038	0.013	14.3	BOTH RESULTS ERRATIC
5018	0.034	0.101		ACCEPTABLE PERFORMANCE
5019	0.037	0.104		ACCEPTABLE PERFORMANCE
5020	0.023	0.096		ACCEPTABLE PERFORMANCE
5021	-0.24	2.77	485.3	BOTH RESULTS ERRATIC
5022	0.0225	0.091		ACCEPTABLE PERFORMANCE
5023	-0.018	0.045	11.5	BIASED LOW, PROBABLE INTERCEPT PROBL
5024	0.025	0.089		ACCEPTABLE PERFORMANCE
5025	0.021	0.043	8.7	ONE RESULT ERRATIC
5026	0.022	0.038	9.6	ONE RESULT ERRATIC
5027	0.012	0.068	4.9	BIASED LOW, POSSIBLE INTERCEPT PROBL
5028	0.046	0.011	14.9	BOTH RESULTS ERRATIC
5029	0.027	0.092		ACCEPTABLE PERFORMANCE
5030	0.024	0.1		ACCEPTABLE PERFORMANCE
5031	0.024	0.087		ACCEPTABLE PERFORMANCE
5032	0.07	0.37	50.8	BIASED HIGH OR ERRATIC
5033	0.03	0.088		ACCEPTABLE PERFORMANCE
5034	0.023	0.094		ACCEPTABLE PERFORMANCE

TARGET	N/A	N/A
MEAN OVERALL	0.017	0.167
MEAN SELECTED	0.026	0.089
MEDIAN OVERALL	0.026	0.090
MEDIAN SELECTED	0.026	0.092
S.OVERALL	0.047	0.457
S.SELECTED	0.008	0.015
# OF PARTICIPANTS	34	34
# SELECTED	29	24

TABLE 9.3.4
MOE INTERLABORATORY STUDY 90-1
EVALUATION E34corr.
(All results are expressed in mg/L)

Lab.Code	E3corr.	E4corr.	Total error	
5001	0.033	0.141	8.9	ONE RESULT ERRATIC
5002	0.04	0.065	4.9	ONE RESULT ERRATIC
5003	0.037	0.084		ACCEPTABLE PERFORMANCE
5004	0.0254	0.0323		ACCEPTABLE PERFORMANCE
5005	0.034	0.107		ACCEPTABLE PERFORMANCE
5006	0.034	0.086		ACCEPTABLE PERFORMANCE
5008	0.000	0.01	15.8	BIASED LOW, PROBABLE SLOPE PROBLEM
5009	0.018	0.102	3.3	ONE RESULT ERRATIC
5010	0.035	0.106		ACCEPTABLE PERFORMANCE
5011	0.018	0.064	5.6	BIASED LOW, PROBABLE SLOPE PROBLEM
5011A	0.034	0.072	3.5	ONE RESULT ERRATIC
5012	0.04	0.088		ACCEPTABLE PERFORMANCE
5013	0.036	0.101		ACCEPTABLE PERFORMANCE
5014	0.0405	0.102		ACCEPTABLE PERFORMANCE
5015	0.048	0.103	3.4	WARNING:BIASED HIGH, PROBABLE INTERC
5016	0.012	0.052	8.0	BIASED LOW, POSSIBLE SLOPE PROBLEM
5017	0.043	0.013	14.2	ONE RESULT ERRATIC
5018		0.101		
5019	0.032	0.104	2.2	WARNING SLIGHT IMPRECISION
5020	0.026	0.096		ACCEPTABLE PERFORMANCE
5021	-0.38	2.77	488.6	BOTH RESULTS ERRATIC
5022	0.0243	0.091		ACCEPTABLE PERFORMANCE
5023	-0.012	0.045	11.6	BIASED LOW: PROBABLE INTERCEPT PROBL
5024	0.033	0.089		ACCEPTABLE PERFORMANCE
5025	0.046	0.043	9.0	BOTH RESULTS ERRATIC
5026	0.013	0.038	10.2	BIASED LOW, PROBABLE SLOPE PROBLEM
5027	0.019	0.068	4.9	BIASED LOW, PROBABLE SLOPE PROBLEM
5028	0.040	0.011	14.7	BOTH RESULTS ERRATIC
5029	0.031	0.092		ACCEPTABLE PERFORMANCE
5030	0.032	0.1		ACCEPTABLE PERFORMANCE
5031	0.03	0.087		ACCEPTABLE PERFORMANCE
5032	0.1	0.37	51.6	BIASED HIGH OR ERRATIC
5033	0.032	0.088		ACCEPTABLE PERFORMANCE
5034	0.023	0.094		ACCEPTABLE PERFORMANCE

TARGET	N/A	N/A
MEAN OVERALL	0.017	0.167
MEAN SELECTED	0.031	0.089
MEDIAN OVERALL	0.033	0.090
MEDIAN SELECTED	0.033	0.092
S.OVERALL	0.073	0.457
S.SELECTED	0.011	0.015
# OF PARTICIPANTS	34	34
# SELECTED	29	24